IS 12225 (1997): Centrifugal jet pump [MED 20: Pumps]

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IS 12225 : 1997

भारतीय मानक

अपकेन्द्री जेट पम्प — विशिष्टि

(पहला पुनरीक्षण)

Indian Standard

CENTRIFUGAL JET PUMP — SPECIFICATION

(First Revision)

ICS 621.671: 621.694

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

December 1997

Price Group 11

Pumps Sectional Committee, HMD 20

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Pumps Sectional Committee had been approved by the Heavy Mechanical Engineerng Division Council.

This standard was first published in 1987. In this revision, a number of modifications have been incorporated, based on the experience gained over the years. The details on installation are omitted, since these are covered in IS 12699 : 1989 'Selection, installation, operation and maintenance of jet centrifugal pump combination — Code of practice'.

The centrifugal jet pumps described in this Standard are those types of pumps, which are capable of lifting ground water from depths beyond 8 m suction lift. This capability becomes in-built in centrifugal jet pump by virtue of the jet unit which is essential part of the centrifugal jet pump.

Among other changes, the tolerances on the various parameters of performance have been revised. An example with typical performance — characteristics of centrifugal jet pump has been included. Considering that jet unit is not an independent item, the pump has been designated as 'Centrifugal Jet Pump'.

For the small capacities and low lifts a special type of pumping unit consisting of a combination of centrifugal pump and a jet pump (Assembly) or ejector has been developed. The centrifugal pump is mounted next to the motor at ground surface and furnishes the driving head and capacity for the jet pump (Assembly) placed in the well below water surface. For shallow wells up to 8 m the jet pump (Assembly) can be placed on the surface of the ground or built into a centrifugal pump casing.

The mechanical advantage of this arrangement is evident as there are no moving parts in the well, and the centrifugal pump, with its motor, can be placed at some convenient point. The hydraulic advantages are steep head capacity characteristics with operating head about 50 percent higher than that of centrifugal pump alone and a brake horse power curve which is non-overloading.

The peak efficiency of the combination is equal to or better than that of jet pump (Assembly) but is lower than that of centrifugal or vertical turbine pumps. However, at the operating capacity the efficiency is equal to or better than that of the centrifugal pumps at the same discharge capacity. In small sizes, this type of pumping unit is widely used for domestic water supply.

The average efficiency of the jet pump (Assembly) unit in the combination is about 32 percent and centrifugal pump efficiency is between 50-75 percent. Total efficiency of the pump increases higher and higher when the delivery is more than the depth to low water level.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

AMENDMENT NO. 1 OCTOBER 2000
TO
IS 12225 : 1997 CENTRIFUGAL JET PUMP — SPECIFICATION

(First Revision)

(*Page* 9, *Table* 1) — Insert the following Note at the end of table:

'NOTE — Depth to Low Water Level (DLWL) mentioned in col 8, 9 and 10 are only indicative and shall depend upon the individual models and the respective DLWL ranges.'

(*Page* 10, *Table* 1A) — Insert the following Note at the end of table:

'NOTE — Depth to Low Water Level (DLWL) mentioned in col 8, 9 and 10 are only indicative and shall depend upon the individual models and the respective DLWL ranges.'

(ME 20)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 2 MARCH 2002
TO
IS 12225:1997 CENTRIFUGAL JET PUMP — SPECIFICATION

(First Revision)

[*Page* 10, *Table* 1A (*see also Amendment No.* 1, *line* 5)] — Substitute 'col 9, 10 and 11' *for* 'col 8, 9 and 10'.

(ME 20)

Reprography Unit, BIS, New Delhi, India

Indian Standard

CENTRIFUGAL JET PUMP — SPECIFICATION

(First Revision)

1 SCOPE

This standard specifies the requirements of single and multistage centrifugal jet pump used for pumping water from wells beyond suction capacity of horizontal/ vertical end suction centrifugal pumps.

2 REFERENCES

The Indian Standards given in Annex A are necessary adjuncts to this standard.

3 PRINCIPLE OF OPERATION OF CENTRIFUGAL JET PUMP

The centrifugal pump (*see* Fig. 1) is primed and started and is made to operate on optimum total head. This head can be created by system delivery head or pressure regulating valve. For efficient operation of the combination, the maximum discharge head (delivery head of centrifugal pump) is to be maintained by adjusting the pressure regulating valve to a total head of centrifugal pump head minus six meters. A part of this pressurized water from the centrifugal jet pump passes through a pressure pipe to Jet pump (Assembly) Nozzle. Above the nozzle, a venturi tube is fitted concentrically in the jet pump (Assembly) body. The nozzle converts all the energy of pressurized water into velocity energy.

This high velocity jet from the nozzle entrains water from the well into the jet body through a foot valve. It also accelerates the surrounding water in the annular area and momentum transfer takes place in the mixing throat of venturi. The kinetic energy of water is converted into pressure energy in the diverging portion of the venturi, called the diffuser. This pressurized water rises to the delivery pipe of the jet pump (Assembly) which in turn acts as a suction pipe of the centrifugal pump, to such a level from which centrifugal pump can pick it up. The quantity drawn from well is delivered as net system discharge and the driving quantity recirculates. The level from which the centrifugal pump picks up is taken as six metres below the centrifugal pump centre line as optimum level, since maximum centrifugal jet pump has centrifugal pump with metric specific speed (nsq) less than 30.

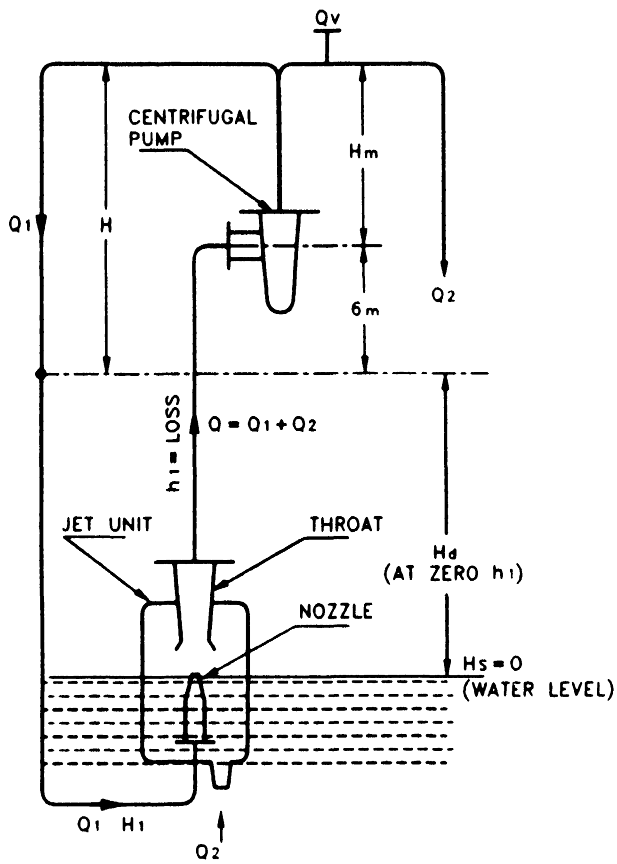


FIG. 1 SCHEMATIC OPERATIONAL DIAGRAM OF A CENTRIFUGAL JET PUMP

4 TYPES OF JET ARRANGEMENT

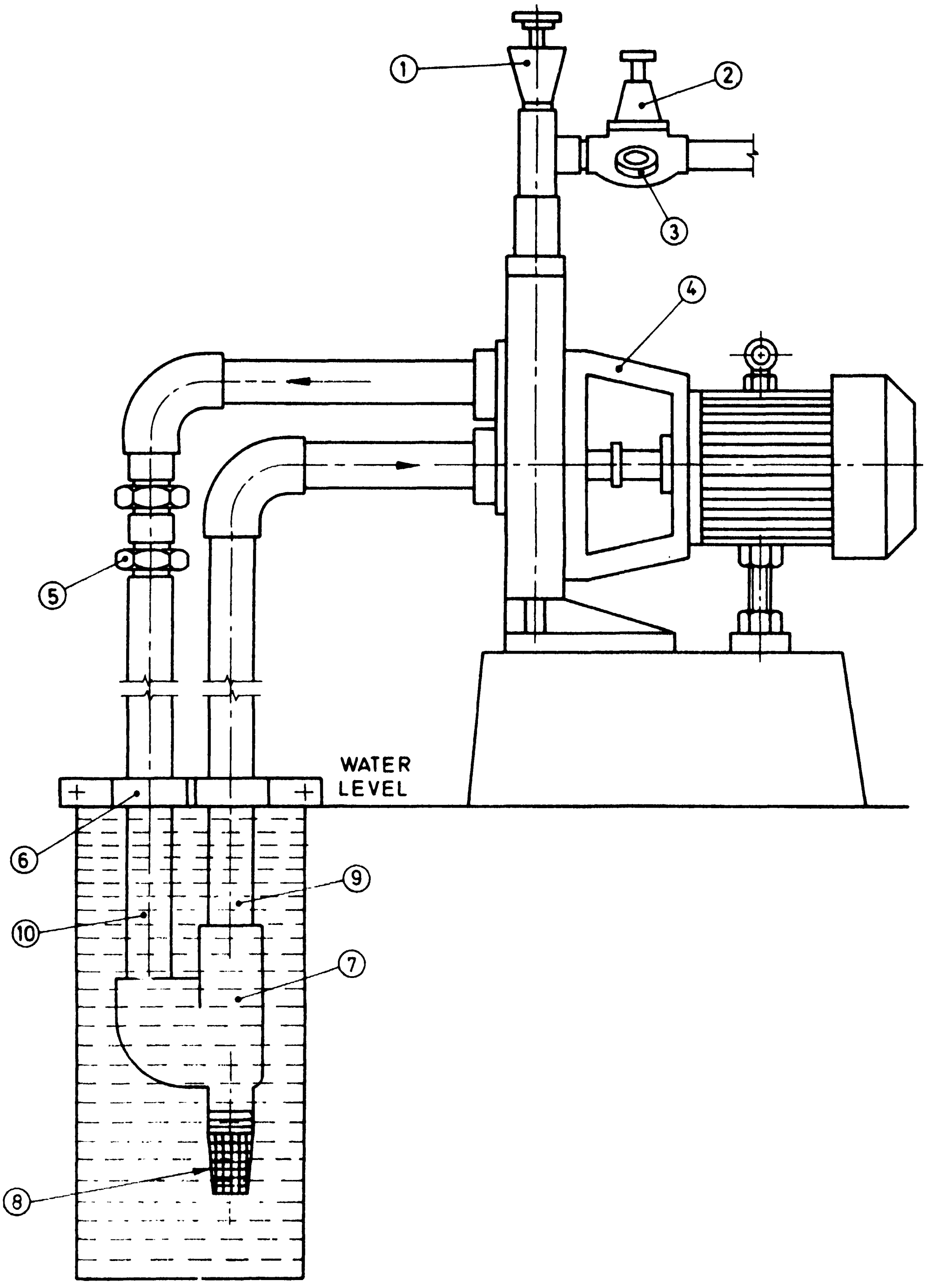
Three types of jet arrangement used in Jet Centrifugal Pumps are given in **4.1**, **4.2** and **4.3**.

4.1 Twin Type

In the twin type of jet arrangement, delivery (suction pipe of centrifugal pump) pipe and pressure pipe connecting the centrifugal jet pump run parallel to each other (*see* Fig. 2).

4.2 Duplex Type

Two concentric pipes are fitted to a duplex type jet arrangement. The inner pipe acts as a delivery pipe



1 Priming Unit
2 Pressure Control Valve
3 Pressure Gauge
4 Mono Pump
5 Slip Coupling
6 Clamp
7 Jet Assembly
8 Foot Valve
9 Delivery Pipe Jet Pump/Suction Pipe of Centrifugal Pump
10 Pressure Pipe

FIG. 2 TYPICAL INSTALLATION FOR TWIN TYPE CENTRIFUGAL JET PUMP

of jet pump (assembly) which in turn is suction pipe of centrifugal pump. The annular area between the outer pipe and the inner pipe acts as pressure pipe to supply water to the jet arrangement nozzle.

Similar to twin type jet arrangement delivery pipe (suction pipe of centrifugal pump) and outer pipe are screwed together to the main jet pump body and are lowered together.

The concentric flow is bifurcated into a twin flow at the ground level by using a duplex head/well adopter, which is connected to the centrifugal pump (*see* Fig. 3).

4.3 Packer Type

The construction of the packer type arrangement is similar to the duplex type except that the bottom portion of the annular space between the two pipes below the nozzle is sealed in a packer housing (*see* Fig. 4 and Fig. 4A). The packers are bucket washer fitted to the bottom-most point of the jet unit. The packer housing is screwed at the bottom-most point of the outer pipe. This enables to lower outer pipe and then inner pipe independently thereby resulting in ease of installation.

5 PUMP AND PRIME MOVER FOR CENTRIFUGAL JET PUMP

5.1 Centrifugal Pumps

Constructional features of the centrifugal pumps may conform to IS 6595(Part 1) or IS 9079.

5.2 Prime Movers

5.2.1 *Motor Drive*

In case of monoset pump, the motor shall conform to the testing requirements given in IS 9079 except for temperature rise test. The temperature rise test shall be conducted at the maximum current, in the operating Depth to Low Water Level (DLWL) range.

5.2.2 *Engine Drive*

In case of Engine monoset the Engine shall conform to IS 7347 or IS 10001 or IS 11170.

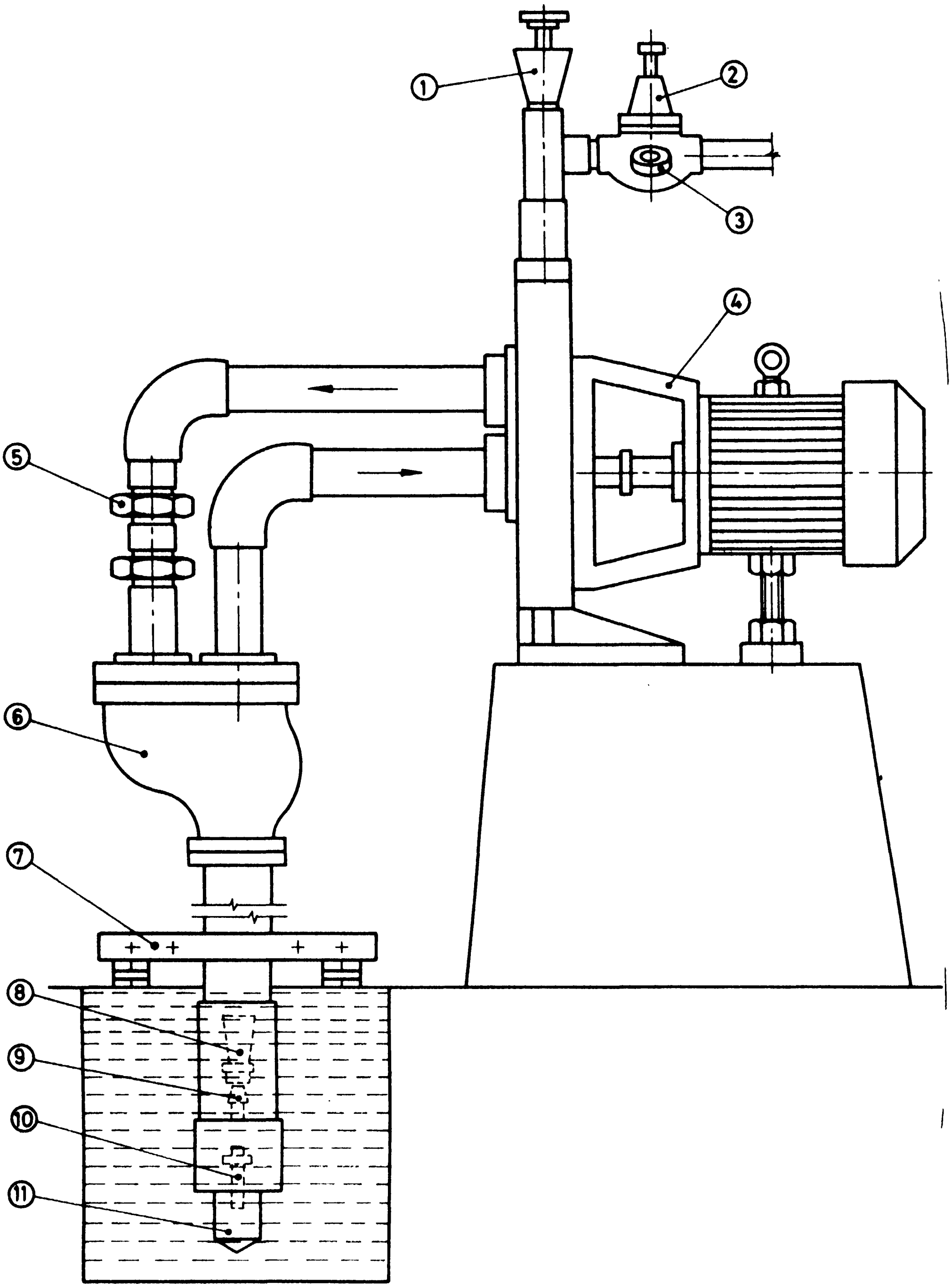
5.2.3 *Coupled and Belt Driven Set*

In case of coupled and belt driven sets calibrated prime mover shall be used for the purpose of testing.

6 MATERIAL OF CONSTRUCTION

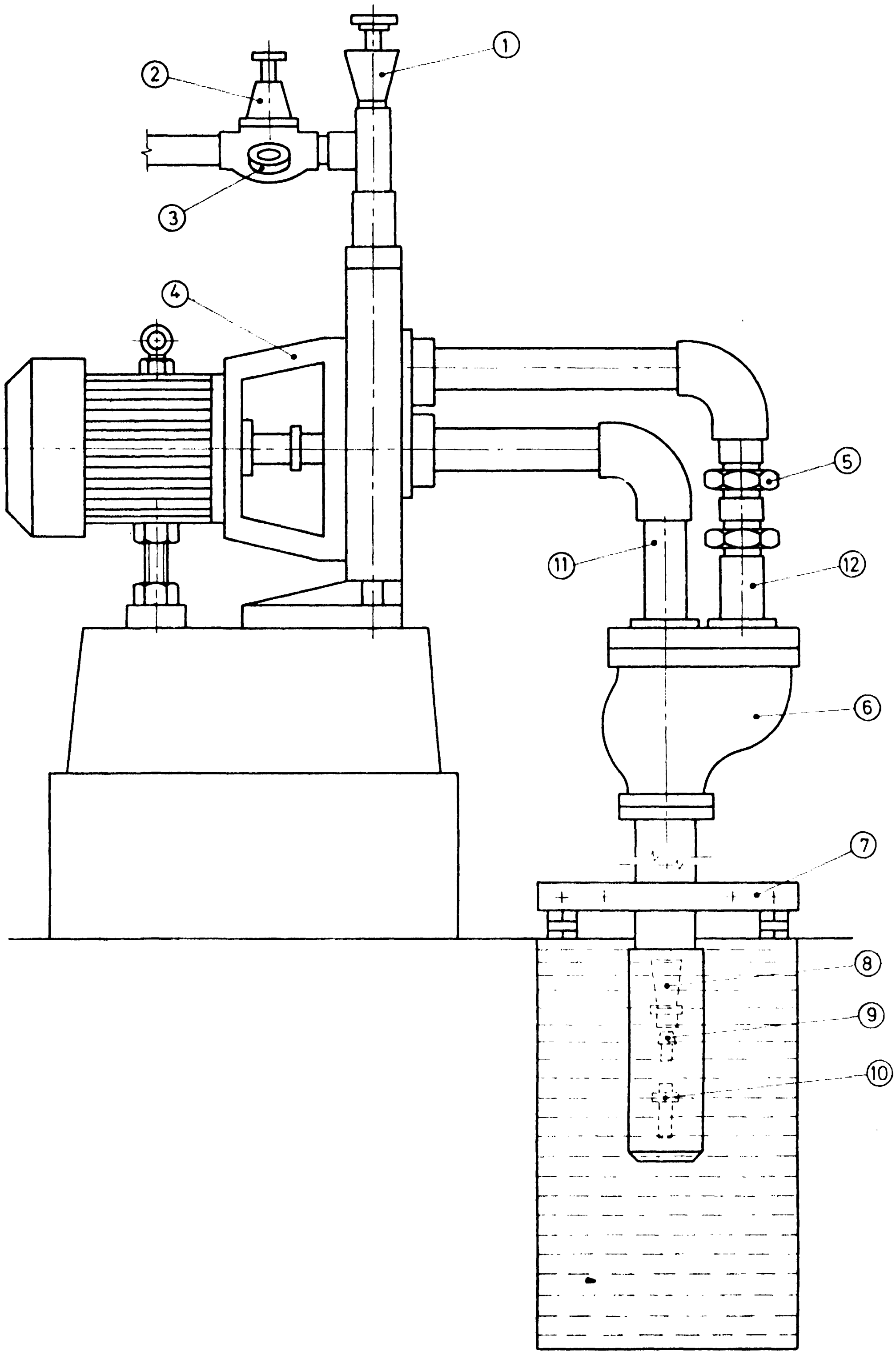
It is recognized that a number of materials of construction are available to meet the needs for centrifugal jet pump. A few typical materials are indicated below for guidance of the manufacturer and the user.

Sl No.	*Components*	*Materials of Construction*
1.	Nozzle	Brass Grade HTB1 of IS 304 or bronze LTB2 of IS 318 or suitable thermoplastics such as polyphenylene oxide (PPO), polycarbonate (PC), acetal (polyacetals) resins, nylon 6 or nylon 66, glass filled nylon, stainless steel grade 04Cr13, 12Cr13, 20Cr13 of IS 6603, cast iron grade FG 200 of IS 210, polytetrafluoroethylene (PTFE), acrylonitrile butadiene styrene copolymers (ABS), polyethylene terephthalate (PET), ultra high molecular weight polyethylene (UHMWPE), etc.
2.	Venturi	Brass grade HTB1 of IS 304 or bronze LTB2 of IS 318 or suitable thermoplastics such as polyphenylene oxide (PPO), polycarbonate (PC), acetal (polyacetals) resins, nylon 6 or nylon 66, glass filled nylon, stainless steel grade 04Cr13, 12Cr13, 20Cr13 of IS 6603, cast iron grade FG 200 of IS 210, polytetrafluoroethylene (PTFE), acrylonitrilebutadiene styrene copolymers (ABS), polyethylene terephthalate (PET), ultra high molecular weight polyethylene (UHMWPE), etc.
3.	Foot Valve	Bronze grade LTB2 of IS 318 or brass grade HTB1 of IS 304 or cast iron grade FG 200 of IS 210 or suitable thermoplastics such as polyphenylene oxide (PPO), polycarbonate (PC), acetal (polyacetals) resins, nylon 6 or nylon 66, glass filled nylon, polytetrafluoroethylene (PTFE), acrylonitrile butadiene styrene copolymers (ABS), polyethylene terephthalate (PET), ultra high molecular weight polyethylene (UHMWPE), etc.
4.	Strainer of Foot Valve	Brass grade HTB1 of IS 304 or suitable thermoplastics such as polypropylene, nylon 6 or nylon 66, cast iron grade FG 200 of IS 210, high density



1 Priming Unit
2 Pressure Control Valve
3 Pressure Gauge
4 Mono Pump
5 Slip Coupling
6 Duplex Head/Well Adopter
7 Clamp
8 Jet Venturi
9 Nozzle
10 Foot Valve
11 Strainer

FIG. 3 TYPICAL INSTALLATION FOR DUPLEX TYPE CENTRIFUGAL JET PUMP



1 Priming Unit
2 Pressure Control Valve
3 Pressure Gauge
4 Mono Pump
5 Slip Coupling
6 Packer Head
7 Clamp
8 Jet Pump Venturi
9 Nozzle
10 Foot Valve
11 Delivery Pipe Jet Pump/Suction Pipe of Centrifugal Pump
12 Pressure Pipe

FIG. 4 TYPICAL INSTALLATION FOR PACKER TYPE CENTRIFUGAL JET PUMP

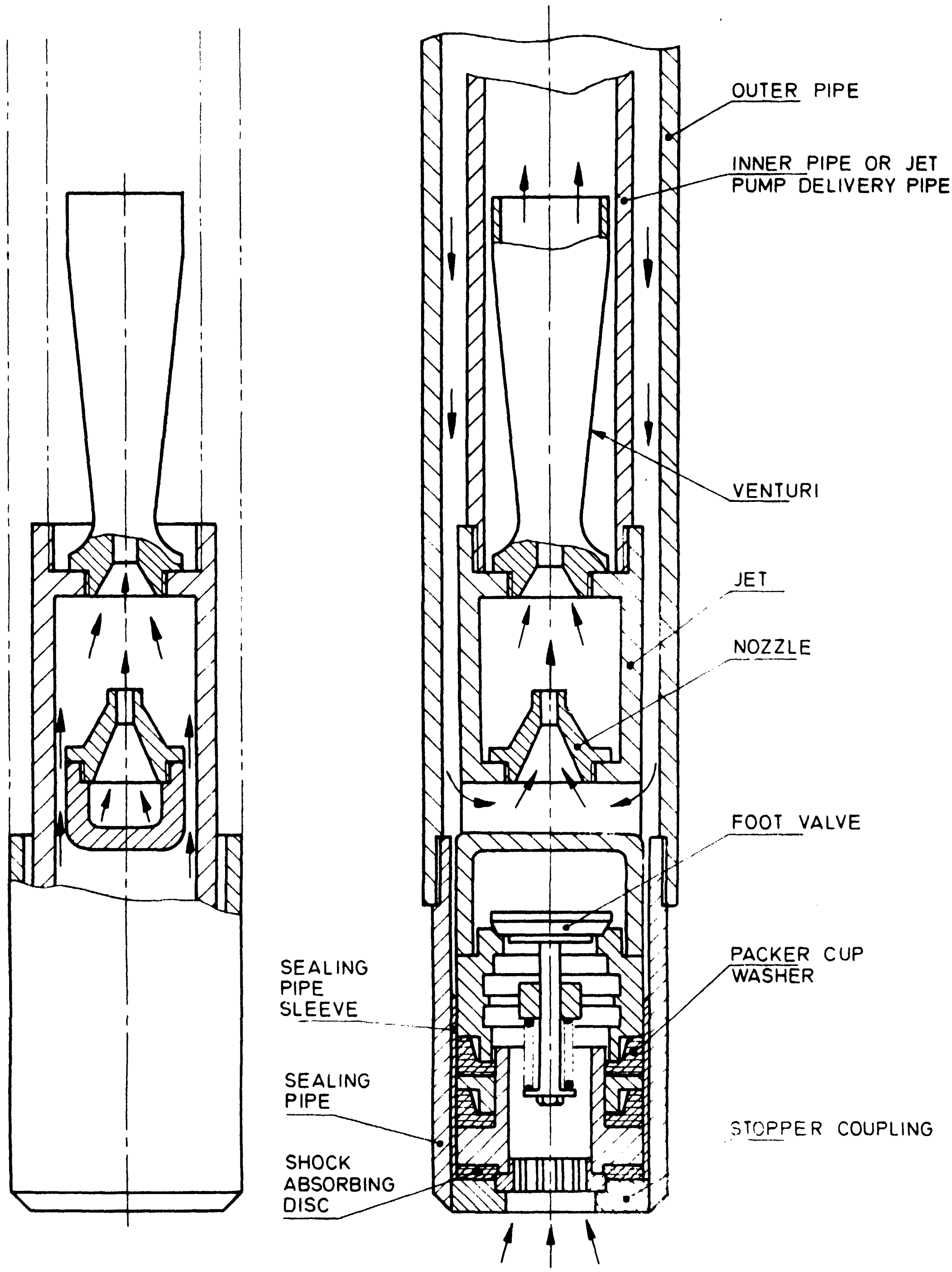


FIG. 4A SECTION THROUGH A PACKER TYPE JET PUMP ASSEMBLY

Sl No.	Components	Materials of Construction
		polyethylene (HDPE), low density polyethylene (LDPE), glass filled nylon, etc.
5.	Jet Pump (Assembly) Body	Cast iron grade FG 200 of IS 210 or bronze grade LTB2 of IS 318 or brass grade HTB1 of IS 304 or suitable thermoplastics such as polyphenylene oxide (PPO), Polycarbonate (PC), acetal (polyacetals) resins, nylon 6 or nylon 66, glass filled nylon, polytetrafluoroethylene (PTFE), etc.
6.	Impeller	Brass grade HTB1 of IS 304 or bronze LTB2 of IS 318, cast iron grade FG 200 of IS 210 or suitable thermoplastics such as polyphenylene oxide (PPO), polycarbonate (PC), acetal (polyacetals) resins, nylon 6 or nylon 66, glass filled nylon, polytetrafluoroethylene (PTFE), acrylonitrile butadiene styrene copolymers (ABS), polyethylene terephthalate (PET), ultra high molecular weight polyethylene (UHMWPE), etc.
7.	Casing	Cast iron grade FG 200 of IS 210 or corrosive resistance alloy steel and nickel base casting for general application (*see* IS 3444) suitable plastic or aluminium magnesium alloys.
8.	Pressure Regulating Valve	
	a) Body	Body Brass Grade HTB1 of IS 304 or bronze LTB2 of IS 318 or suitable thermoplastics such as polyphenylene oxide (PPO), polycarbonate, acetal (polyacetals) resins, nylon 6 or nylon 66, glass filled nylon, stainless steel grade 04Cr13, 12Cr13, 20Cr13 of IS 6603, cast iron grade FG 200 of IS 210, polytetrafluoroethylene (PTFE), acrylonitrile butadiene styrene copolymers (ABS), polyethylene terephthalate (PET), ultra high molecular weight polyethylene (UHMWPE), etc.
	b) Diaphragm	Neoprene rubber or nitrile rubber.
	c) Valve Seat	Bronze grade LTB2 of IS 318 or suitable thermoplastics such as polyphenylene oxide (PPO), polycarbonate (PC), acetal (polyacetals) resins, nylon 6 or nylon 66, glass filled nylon, polytetrafluoroethylene (PTFE), acrylonitrile butadiene styrene copolymer (ABS), polyethylene terephthalate (PET), ultra high molecular weight polyethylene (UHMWPE), etc.
9.	Slip Coupling (Optional) for Twin Type	
	a) Body	Cast iron grade FG 200 of IS 210.
	b) Sealing Ring	Neoprene rubber or nitrile rubber.
10.	Packer Head/ Duplex Head and Flanges	Cast iron grade FG 200 of IS 210.

NOTES

1 The materials listed are to be considered as only typical and indicative of minimum requirements of the materials properties. The use of materials having better properties is not prejudiced by the details above, provided materials for components in bearing contact with each other do not entail galling, corrosion, magnetic induction, etc.

2 IS 6603 is under revision and designations referred here are likely to be aligned with IS 1570 (Part 5) in the revision.

7 SELECTION OF CENTRIFUGAL JET PUMP

Centrifugal jet pump shall be selected according to IS 12699.

8 PERFORMANCE CHARACTERISTICS

8.1 Factor Affecting Performance

The submergence of jet pump (Assembly) below water level affects the overall performance of the centrifugal jet pump. All the capacities shall be given for the pump offset from well of 1.5 m for horizontal jet and the submergence of jet pump (Assembly) shall be specified by the manufacturer along with minimum operating pressure. The method of obtaining higher submergence by supplying the input water to the jet

pump (Assembly) foot valve through pressure tank shall be as given in Annex B and Fig. 5. Submergence is the level of water above the nozzle of the jet unit.

8.2 Performance Curves

The tabulated readings shall be drawn as a set of performance curves.

a) Discharge Q_2 *vs* total head,
b) Discharge Q_2 *vs* depth to low water level for centrifugal jet pump,
c) Discharge Q_2 *vs* power input, and
d) Discharge Q_2 *vs* current.

8.3 The performance of centrifugal jet pump shall be given as shown in Table 1 and Table 1A by the manufacturer.

9 TESTING

9.1 Method of Testing

Centrifugal jet pump shall be fitted with the jet pump (Assembly) through proper sizes of pipes of required lengths with respective orifice plates. One pressure gauge shall be fitted to the delivery pipe of the jet pump (Assembly) which is the suction pipe of the centrifugal pump. Another pressure gauge shall be fitted to the discharge pipe (delivery pipe of centrifugal pump) of the centrifugal jet pump. The electric motor shall be connected to the pump. The pump is primed and the motor is switched on. By throttling the discharge valve, the following readings shall be taken:

a) Total head (on the pressure gauge connected to the discharge pipe which is delivery pipe of centrifugal pump),
b) Corrected ejector head (on the pressure gauge connected to the suction pipe of the centrifugal pump which is the delivery pipe of the jet pump (Assembly),
c) Discharge,
d) Power input,
e) Speed of the motor,
f) Voltage, and
g) Current.

The above readings shall be tabulated in the form of a test report for each pump as given in Table 2.

Atleast three test points, that is, duty point, maximum and minimum head shall be taken. The manufacturer shall give the maximum jet setting depth (ejector head + 6 m) for the various types of pumps offered at which the maximum ejector efficiency is obtained. All the heads, discharge and power shall be corrected to the rated speed.

9.2 Testing Method for Centrifugal Jet Pump for Including Pipe Friction by the Use of Orifice Plate

The depth to low water level, total head, discharge and power input shall be declared by the manufacturer at the duty point and the testing shall be carried out only for the duty point declared by the manufacturer.

Orifice plates as shown in Fig. 6 with diameters calculated in accordance with the procedure given in Annex C shall be used in the pressure pipe and the delivery pipe (suction pipe of centrifugal pump) of the centrifugal jet pump to take into account the field friction. Examples are given in Annex C with Fig. 5, 8,10,11,12 and 13 which give the schematic and test set up diagram for twin, packer and duplex type centrifugal jet pump.

9.3 Pressure Testing

The pump casing and the jet unit shall be hydraulically tested to minimum 1.5 times the system's maximum pressure.

10 TOLERANCES

At rated speed the pump shall give a minimum of 92 percent of the rated depth to low water level and minimum of 92 percent of the rated total head at a minimum of 92 percent rated discharge. The pump shall not take more than 110 percent of the declared power input in the range between 92 percent of the rated discharge to rated discharge. The maximum current in the operating range of depth to low water level shall not exceed the 107 percent values specified in IS 996 or IS 7538 as the case may be in order to avoid overloading of the prime mover. For 2 pole single phase motor, the value of maximum full load current shall be declared by the manufacturer. An example is given in Annex D with Fig. 11 to 13.

11 SAMPLING

The sampling shall be as specified in IS 10572.

12 MARKING

12.1 The manufacturer shall furnish the following information:

a) Depth to low water level, that is, the distance from centrifugal pump base centre line (for vertical pump) and suction inlet centre line (for horizontal pump) to the water level in m;
b) Discharge in l/h;
c) Submergence at duty point in m;
d) i) For duplex/packer type:

   Outer/Inner/Pressure/discharge (delivery of centrifugal pump) pipe sizes in mm, and

Table 1 Performance of Twin Type Centrifugal Jet Pump

(*Clause* 8.3)

Single Phase/ Three Phase

Rating	Jet Unit Code	Pressure Pipe Dia	Delivery Pipe Dia of Jet Assembly (Suction Pipe of Centrifugal Pump)	Discharge Pipe Dia (Delivery Pipe of Centrifugal Pump)	Minimum Clear Bore Dia	Minimum Operating Pressure/ Discharge Head (Delivery Head of Centrifugal Pump)	Capacity for Different Depths to Low Water Level from Centrifugal Pump Centre		
		mm	mm	mm	mm	m	l/h		
							9 m	15 m	25 m onwards
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)

Table 1A Performance of Packer/Duplex Centrifugal Jet Pump

(*Clause* 8.3)

Single Phase / Three Phase
Type: Packer/Duplex

Rating	Jet Unit Code	Outer Pipe Dia	Inner Pipe Dia	Pressure Pipe Dia	Discharge Pipe Dia (Delivery Pipe Dia of Centrifugal Pump)	Minimum Clear Bore Dia	Minimum Operating Pressure/ Discharge Head (Delivery Head of Centrifugal Pump)	Capacity for Different Depths to Low Water Level from Centrifugal Pump Centre		
								l/h		
		mm	mm	mm	mm	mm	m	9 m	15 m	25 m onwards
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)

Table 2 Test Report for Contrifugal Jet Pump

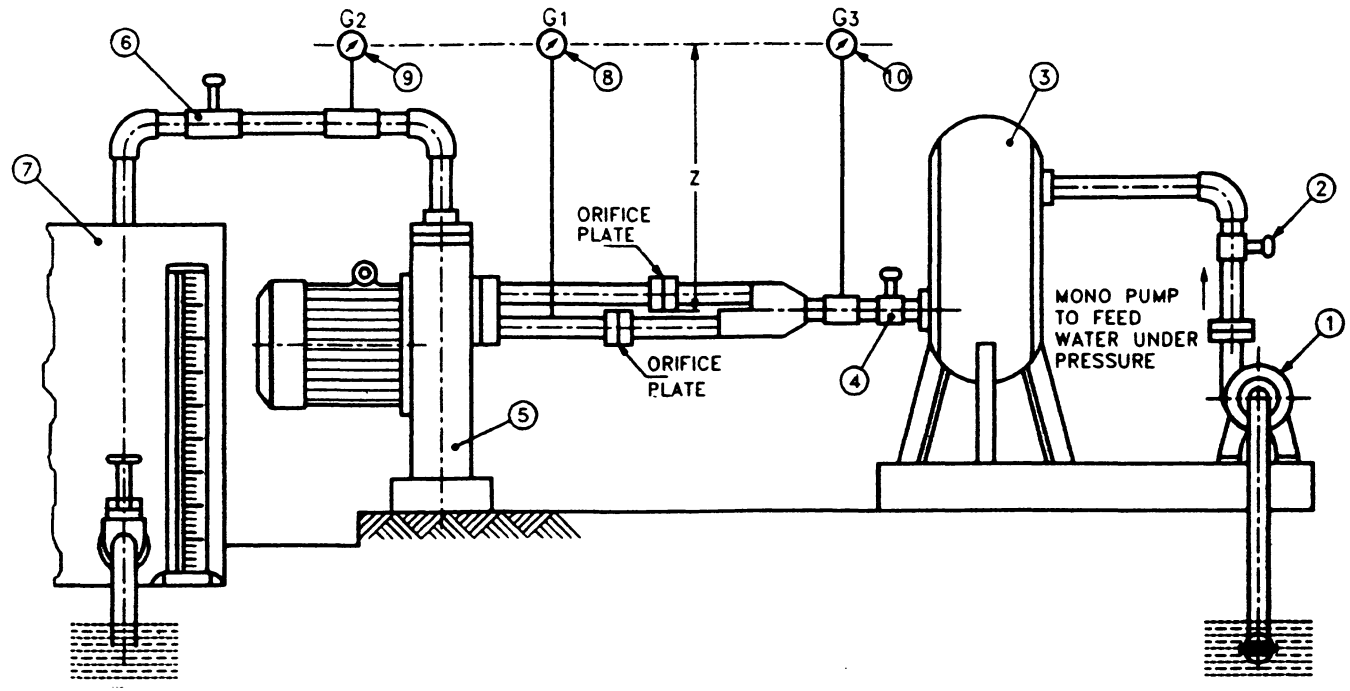
(*Clause* 9.1)

Single/Three Phase

Ref :

Name of the manufacturer:	kW/HP:	Pipe size in mm:
Discharge in 1/h:	Centrifugal jet pump Sl.No.:	Duplex/Packer Type:
Maximum jet OD in mm:	Bore size in mm :	Outer/Inner/Pressure discharge (Centrifugal pump delivery):
Depth to low water level (DLWL):	Total head in m:	Twin type jet pump:
Rated speed in rev/min:	Frequency:	Jet delivery/Pressure discharge (Centrifugal pump delivery):

Sl No.	Speed	Depth to Low Water Level			Total Head			Actual Dis-charge	Voltage	Current	Motor Input	Performance at Rated Speed				Re-marks
		Ejector Head	Correc-tion on	DLWL	Dis-charge Gauge Reading	Correc-tion on Head	Total Head					Rated DLWL	Rated Total Head	Rated Dis-charge	Rated Motor Input	
		G_1	Z_1	G_1+Z_1+6	G_2	Z_2	G_2+Z_2									
	rev/min	m	m	m	m	m	m	1/h	V	A	kW	m	m	1/h	kW	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17



1 Pump
2 Gate Valve-1
3 Pressure Tank
4 Gate Valve-2
5 Mono Set Jet Centrifugal Pump Combination
6 Gate Valve-3
7 Collecting Tank
8 Pressure Gauge G_1 – (Ejector Head)
9 Pressure Gauge G_2 – (Total Head)
10 Pressure Gauge G_3 – (Submergence)

NOTE — Net Ejector head — $(G_1 + Z) - (G_3 + Z)$

Net Total Head = $(G_2 + Z) - (G_3 + Z)$

FIG. 5 INSTALLATION FOR TYPICAL TEST SET UP FOR JET CENTRIFUGAL PUMP COMBINATION WITH SUBMERGENCE

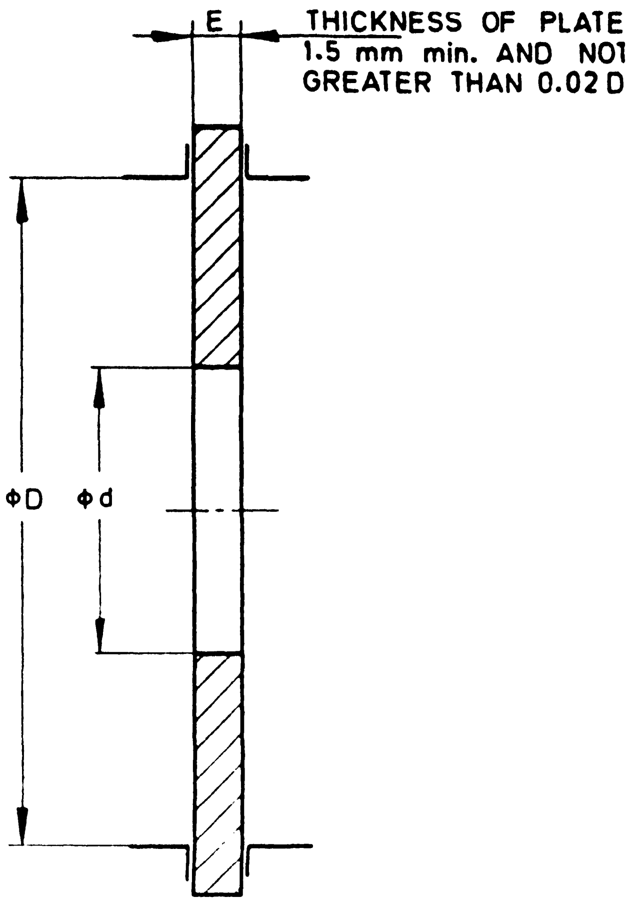


FIG. 6 SYMMETRICAL ORIFICE PLATE

ii) For twin type:

Jet delivery (centrifugal pump suction), pressure/ discharge (delivery of centrifugal pump) pipe sizes in mm;

e) Depth to low water level range in m;

f) Total head (depth to low water level + discharge head) in m;

g) Power input in kW;

h) Rated speed in rev/min; and

i) Maximum current in A.

12.2 Standard Marking

12.2.1 The centrifugal jet pump may also be marked with the Standard Mark.

12.2.2 The use of Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which a licence for the use of Standard Mark may be granted to manufacturers or producers, may be obtained from the Bureau of Indian Standards.

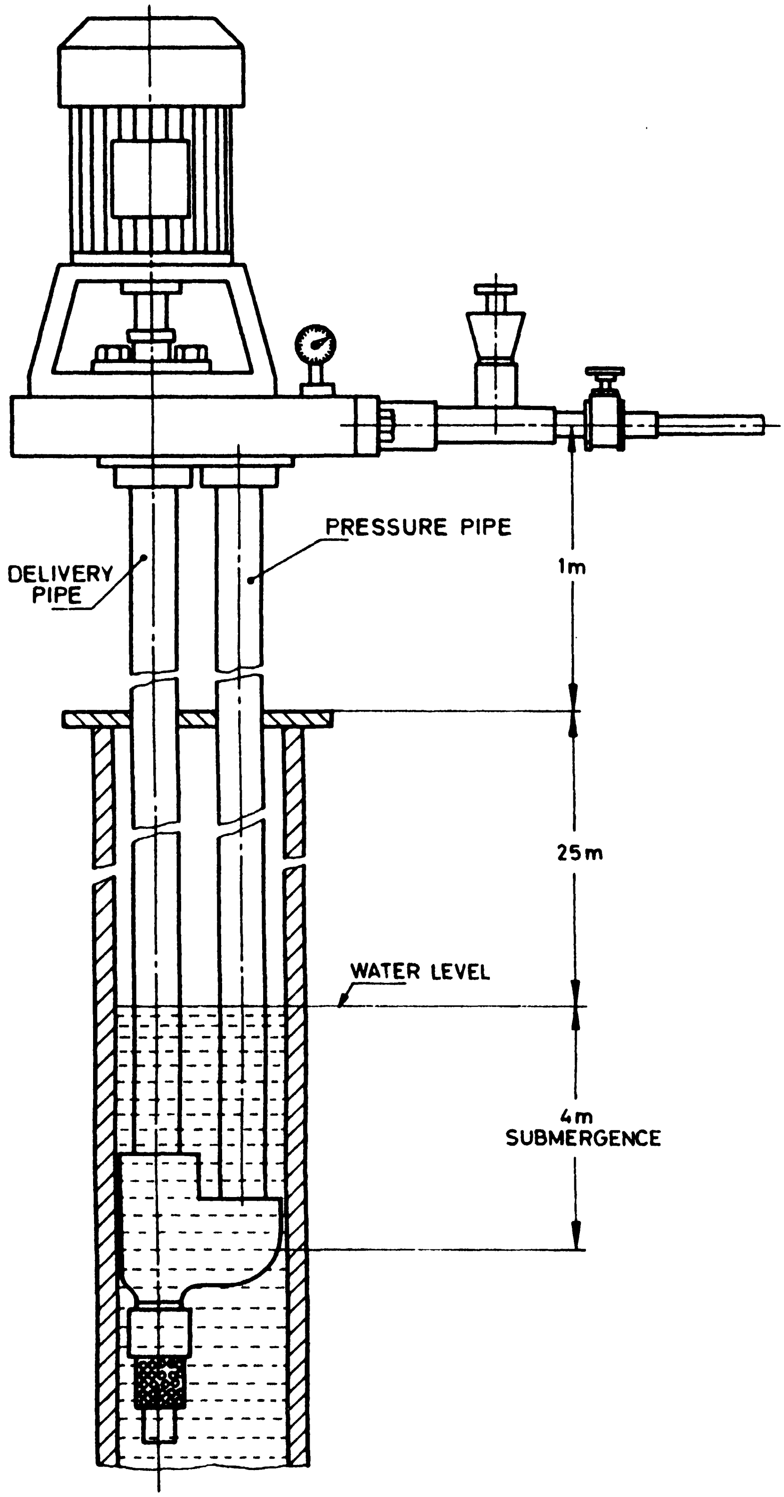


FIG. 7 FIELD INSTALLATION DIAGRAM FOR VERTICAL TWIN TYPE CENTRIFUGAL JET PUMP

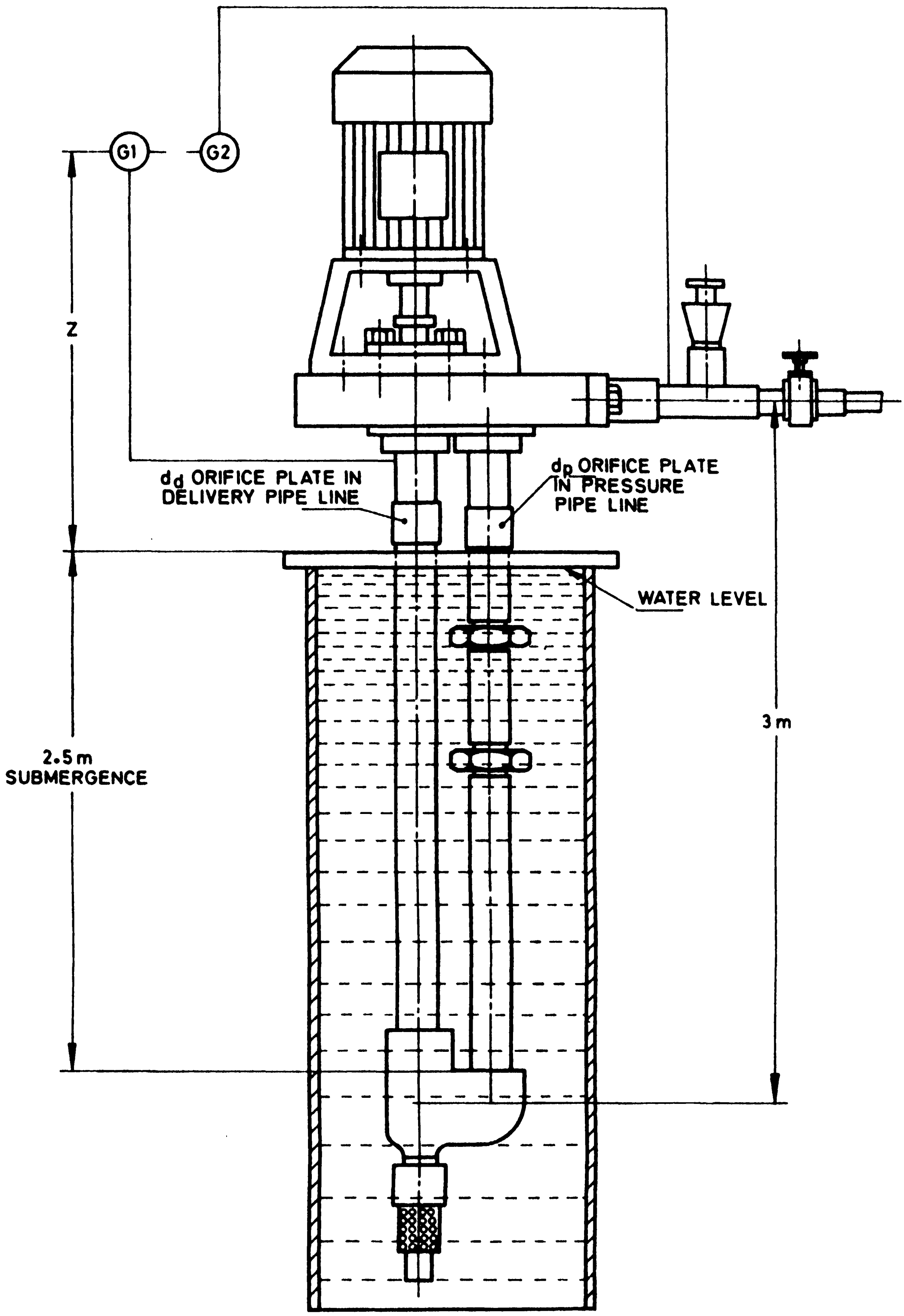
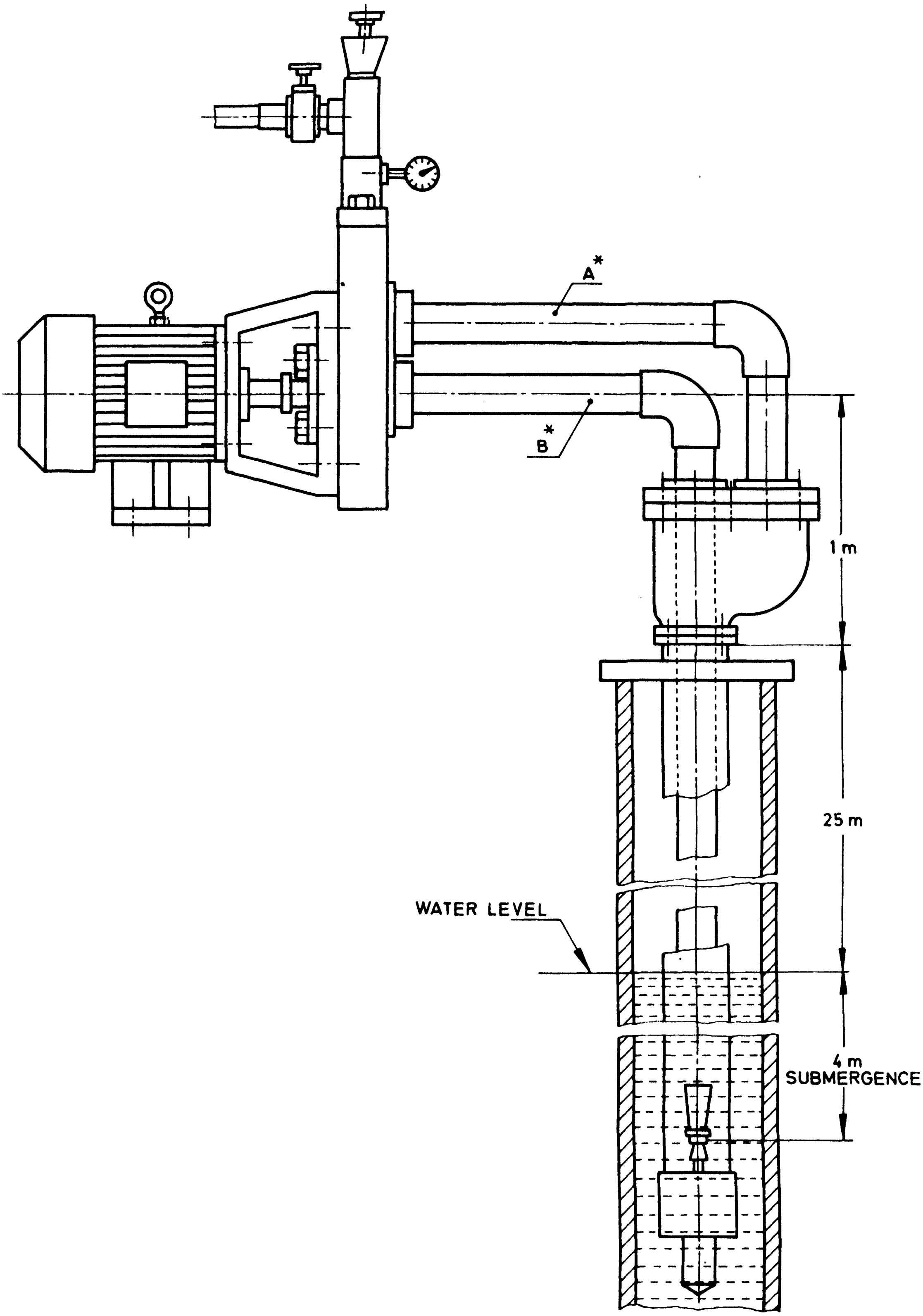
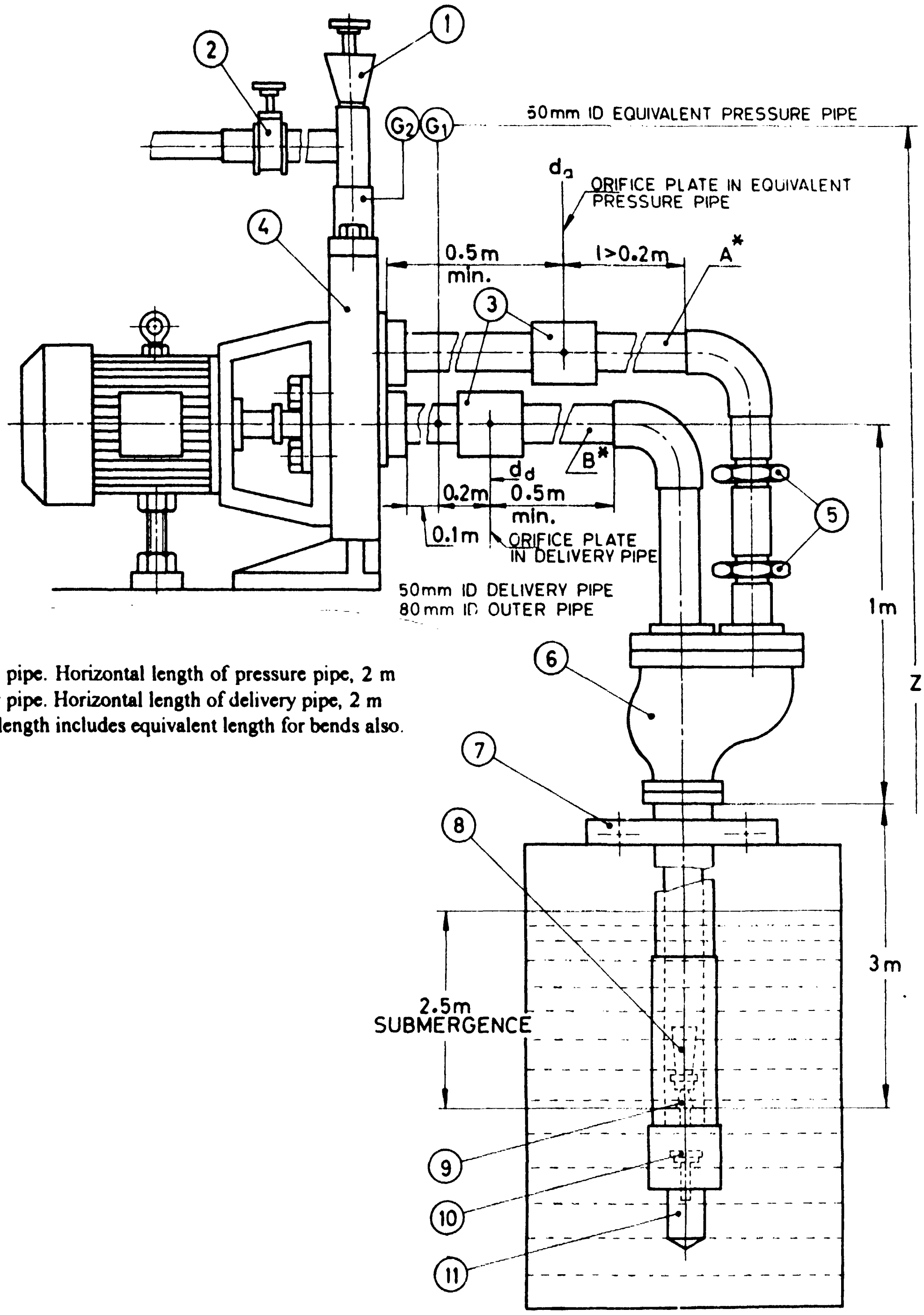


FIG. 8 TESTING INSTALLATION DIAGRAM FOR TWIN TYPE CENTRIFUGAL JET PUMP



A = Horizontal length of pressure pipe, 3 m
B = Horizontal length of delivery pipe, 3 m
* Horizontal length includes equivalent length for bends also.

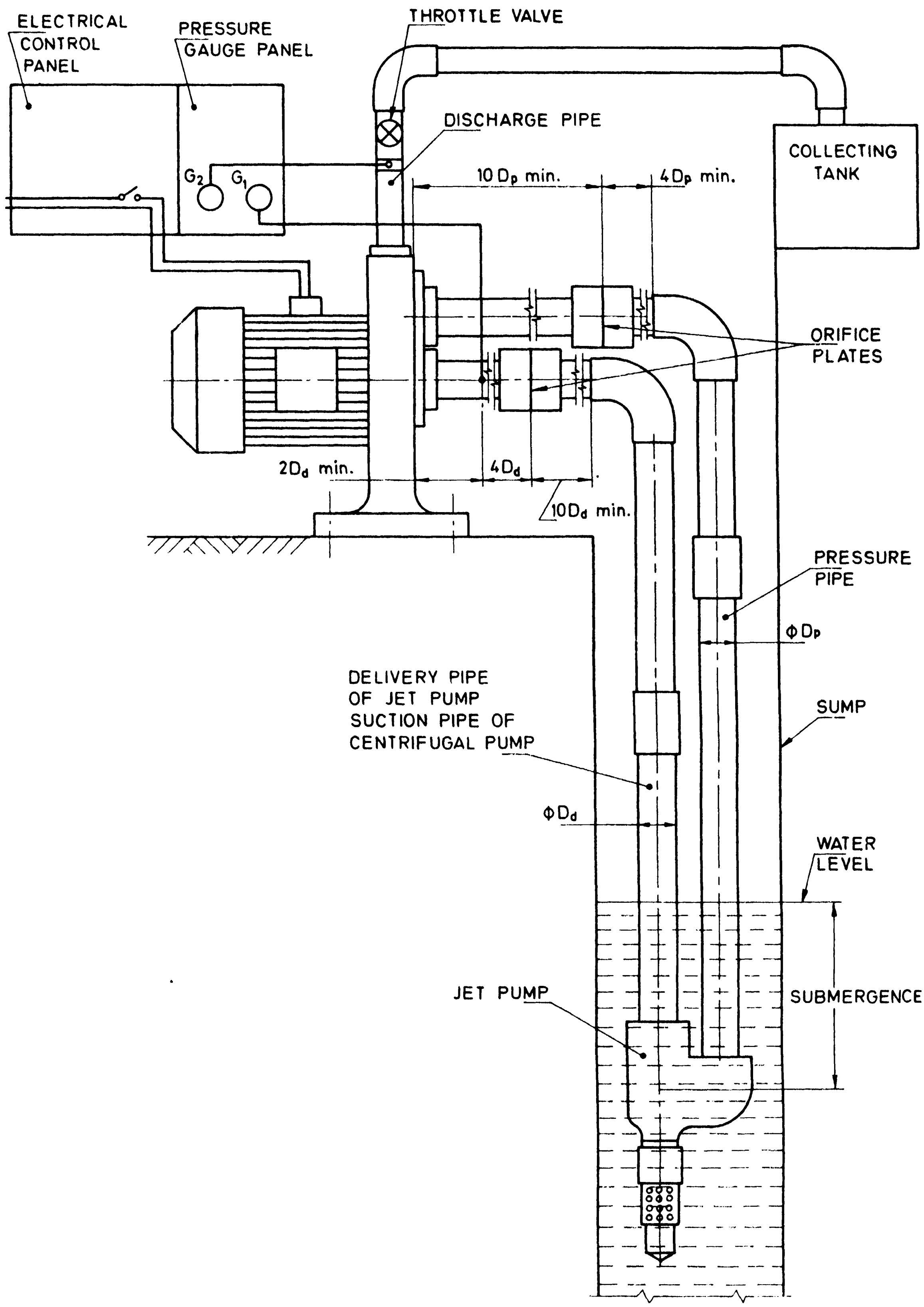
FIG. 9 FIELD INSTALLATION FOR HORIZONTAL DUPLEX TYPE CENTRIFUGAL JET PUMP



A = Pressure pipe. Horizontal length of pressure pipe, 2 m
B = Delivery pipe. Horizontal length of delivery pipe, 2 m
* Horizontal length includes equivalent length for bends also.

1 Priming Unit
2 Pressure Control Gate Valve
3 Orifice Plates d_a and d_d
4 Mono Pump
5 Slip Coupling
6 Duplex Head/Well Adopter
7 Clamp
8 Jet Venturi
9 Nozzle
10 Foot Valve
11 Strainer

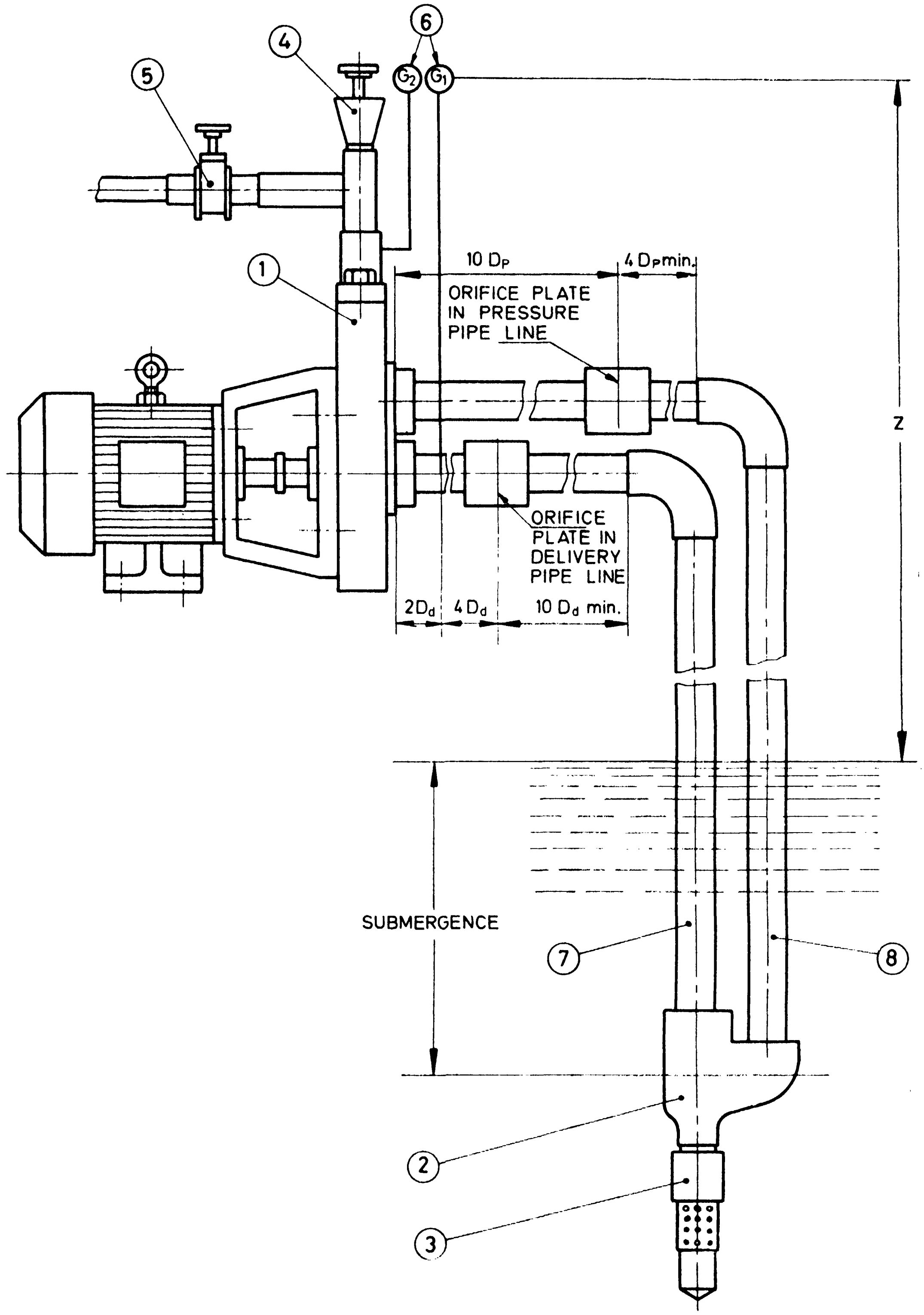
FIG. 10 TESTING INSTALLATION FOR DUPLEX TYPE CENTRIFUGAL JET PUMP FOR FACTORY SET UP



G_1 — Pressure gauge fitted in suction pipe of centrifugal pump which is the delivery pipe of jet pump.
G_2 — Pressure gauge fitted in discharge pipe.

NOTE — Ejector head = $G_1 + Z$, Total head = $G_2 + Z$

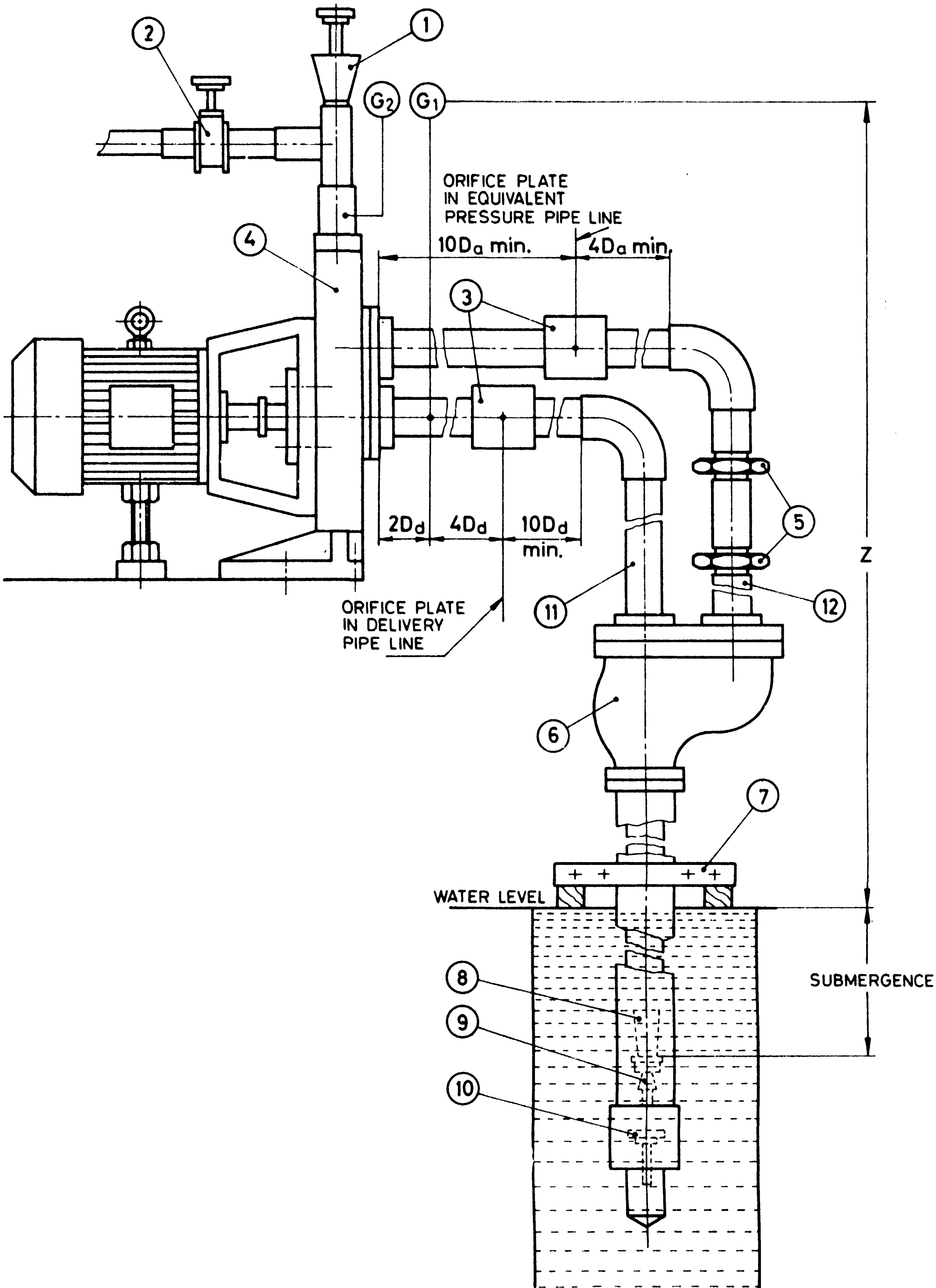
FIG. 11 SCHEMATIC TESTING ARRANGEMENT OF MONOSET CENTRIFUGAL JET PUMP



1 Mono Pump
2 Jet Unit
3 Foot Valve with Strainer
4 Priming Unit
5 Pressure Control Gauge Valve
6 Pressure Gauge G_1 and G_2
7 Suction Pipe of Centrifugal Pump/Delivery Pipe of Jet Pump (D_d)
8 Pressure Pipe (D_p)

NOTE — The orifice plate shall be installed at a minimum distance of 10 *D* from bend on the upstream side and pressure gauge shall be installed at minimum of 4 *D* on the downstream side of onfice plate.

FIG. 12 TESTING INSTALLATION FOR HORIZONTAL TWIN TYPE CENTRIFUGAL JET PUMP



1 Priming Unit
2 Pressure Control Gate Valve
3 Orifice Plates d_a and d_d
4 Mono Pump
5 Slip Coupling
6 Packer/Duplex Head
7 Clamp
8 Jet Pump Venturi
9 Nozzle
10 Foot Valve
11 Delivery Pipe of Jet Pump/Suction Pipe of Centrifugal Pump (D_d)
12 Equivalent Pressure Pipe (D_a)

FIG. 13 TESTING INSTALLATION FOR PACKER/DUPLEX TYPE CENTRIFUGAL JET PUMP

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
210 : 1993	Grey iron castings (*fourth revision*)
304 : 1981	High tensile brass ingots and castings (*second revision*)
318 : 1981	Leaded tin bronze ingots and castings (*second revision*)
996 : 1979	Single phase small ac and universal electric motors (*second revision*)
3444 : 1987	Corrosion resistant alloy steel and nickel base castings for general applications (*second revision*)
6595 (Part 1) : 1993	Horizontal centrifugal pumps for clear cold water : Part 1 Agriculture and rural water supply purposes (*second revision*)
6603 : 1972	Stainless steel bar and flats. (*under revision*)
7347 : 1974	Performance of small size spark ignition engines for agricultural sprayers and similar applications
7538 : 1975	Three phase squirrel cage induction motors for centrifugal pumps for agricultural applications
9079 : 1989	Monoset pumps for clear cold water for agricultural purposes (*first revision*)
10001 : 1981	Performance requirements for constant speed compression ignition (diesel) engines for general purposes
10572 : 1983	Method of sampling pumps
11170 : 1985	Performance requirements for constant speed compression ignition (diesel) engines for agricultural purposes
12699 : 1989	Code of practice for selection, installation, operation and maintenance of combination centrifugal jet pump

ANNEX B

(*Clause* 8.1)

METHOD OF TESTING CENTRIFUGAL JET PUMP WITH REQUIRED SUBMERGENCE

B-1 GENERAL

The Submergence of the jet unit below the water level affects the performance of centrifugal jet pump drastically. A jet pump (Assembly) with inadequate submergence causes cavitation at the mixing point and great loss in performance.

Every pump has to be declared with the required submergence for optimum performance of the centrifugal jet pump.

In the test set up, it becomes sometimes impractical to locate the jet unit with the required submergence since it is very high.

In order to stimulate a pressure tank is used in the test set up as shown in Fig.5:

a) A pressure tank of atleast 5 to 6 times the maximum discharge capacity of centrifugal jet pump in l/min to be tested.

b) A centrifugal pump with a head of atleast 1.5 times that of the maximum submergence pressure to be created in the pressure tank, with a discharge capacity of atleast twice the maximum discharge of centrifugal jet pump.

The pressurizing centrifugal pump (1) is connected to the pressure tank through throttle valve (2) and foot-valve. The pressure tank is connected to the centrifugal jet pump through throttle valve (4) at the foot-valve entry. A pressure gauge (10) reads the pressure (G_3) at the entry to centrifugal jet pump. A pressure guage (8) reads the ejector head pressure (G_1) in the delivery pipe of jet pump (Assembly) which in turn is the suction pipe of the centrifugal pump of centrifugal jet pump. A pressure gauge (G_2) reads the total head developed by the centrifugal jet pump. Orifice plates are introduced in the pressure and delivery pipes, to take care of field pipe friction (*see* Fig. 5).

B-2 TESTING PROCEDURE

The pressurizing centrifugal pump (1) is started and the valves (2) and (4) are adjusted such that the gauge (10) shows a head nearer to the required declared submergence.

The throttle valve (6) is adjusted in such a way that gauge (G_1) shows a ejector head nearer to the duty point ejector head plus submergence.

Adjust the valves (2) and (4) such that a steady reading of G_3 (duty point submergence) and G_1 (duty point ejector head + G_3) is reached.

Then, measure Q1, the volume rate of flow, with the help of collecting tank and power input to the pump.

Then, the head readings for given submergence of G_3 are:

$$(G_2 + Z) - (G_3 + Z) = \text{Total head}$$

$$(G_1 + Z) - (G_3 + Z) = \text{Ejector head}$$

ANNEX C

(*Clause* 9.2)

TESTING METHOD FOR CENTRIFUGAL JET PUMP INCLUDING PIPE FRICTION BY THE USE OF ORIFICE PLATES IN TEST SET UP

C-1 GENERAL

The effect of friction in the length of delivery pipe and pressure pipe in the centrifugal jet pump is stimulated by means of orifice plates in the delivery and pressure pipes. The diameter of the orifice plate is found by means of equating the head loss in friction in the corresponding pipe lengths in field use to the head loss by sudden contraction and expansion by the introduction of orifice plates.

For twin type pumps, the orifice plates are introduced in the corresponding pipe lengths in the test set up. For packer type pump, the loss in friction is found for the annular area between the outer pipe and the delivery pipe in terms of an equivalent diameter of a pressure pipe, and in this pipe, the orifice plate is introduced. The method of locating orifice plates in the test set-up is shown in Fig. 5, 8, 10, 11, 12 and 13 for different types of pumps. The methods for calculating the diameter of orifice plate shall be as given in **C-2** to **C-4**. The nominal pipe size and corresponding pipe inner diameter for calculation of orifice plates are given in Table 3.

Table 3 Pipe Inner Diameter for Nominal Sizes of Pipes

(*Clause* C-1)

Nominal Pipe Sizes in mm	20	25	32	40	50	65	80	100
Pipe inner diameter for calculation of orifice plates in mm	22	27	36	42	53	69	81	106

C-2 SELECTION OF ORIFICE DIAMETER

C-2.1 Terminology

L = length of pipe line;

D_d = inner diameter of delivery pipe of jet unit for twin, packer and duplex;

D'_d = outer diameter of delivery pipe of jet unit for duplex and packer only;

D_p = inner diameter of pressure pipe;

D_o = inner diameter of outer pipe in duplex/ packer type pump;

d_p, d_d, d_a = inner diameter of orifice plates for pressure pipe, delivery pipe and equivalent pipe, respectively;

h_f = head loss in friction in the length;

h = head loss in orifice plate;

f = Darcy-weisbech friction factor;

C = discharge coefficient;

α = CE = flow coefficient;

β = (d_d/D_d) or (d_p/D_p) or (d_a/D_o);

= diameter ratio of orifice plate to pipe inner diameter;

E = Velocity approach factor;

$= (1-\beta^4)^{-1/2}$

ρ = Mass density = w/g;

Q = qm/ρ = volume rate flow; and

$$V = \frac{Q}{(\pi/4)\,D^2}$$

$= Q/A$

where

A = area of pipe

Δp = pressure loss in orifice plate, and

$\Delta p/w$ = head loss in orifice plate

C-2.2 The average value of $C = 0.6$ and $f = 0.027\,8$ has been taken after considering the different diameters of pipe diameter ratio and life of pipe. A 10 percent error in the above results affects only the overall result of pump performance by one percent.

If d is the orifice plate inner diameter:

$$qm = \alpha\,(\pi/4) d^2 \sqrt{2\,(\Delta p\rho)}$$

Substituting

$$qm = PQ$$

$$Q = CE(\pi/4)d^2 \sqrt{2\,(\Delta p\rho/\rho^2)}$$

$$= CE(\pi/4)d^2 \sqrt{2\,(\Delta p/w)g}$$

$$= CE(\pi/4)d^2 \sqrt{2gh}$$

$$= CE(\pi/4)D^2 \beta^2 \sqrt{2gh}$$

$$= CE\beta^2 (\pi/4)D^2 \sqrt{2gh}$$

$$Q = CE\beta^2 A\sqrt{2gh}$$

But $Q/A = V$, therefore squaring both the sides and equating, we get:

$$h = (V^2/2g) \times \frac{1}{C^2(E\beta^2)^2}$$

$$\text{But } E\beta^2 = \frac{\beta^2}{(1-\beta^4)^{1/2}}$$

$$= \frac{1}{(1/\beta^4-1)^{1/2}}$$

$$(E\beta^2)^2 = \frac{1}{(1/\beta^4-1)}$$

$$h = [(V^2/2g)]\,[(1/\beta^4-1)/C^2]$$

For any pipe,

Allowing for pressure recovery after orifice plates, we can write

$$Kh = h_f$$

where K is 0.9 up to 40 mm sizes of pipe and 0.8 for higher pipe sizes.

$$h_f = [\,(fL/D)] \times (V^2/2g)$$

We get,

$$1/\beta^4 = [C^2 f(L/KD)+1] \text{ from } [C^2 f(L/KD)]$$

$$= (1/\beta^4 - 1)$$

Substituting β = d/D

$$D^4/d^4 = [C^2(fL/KD)+1]$$

$$d = \frac{D}{[C^2(fL/KD)+1]^{0.25}}$$

Substituting value of $C = 0.6$ and $f = 0.027\,8$, the final equation for the diameter of orifice plate as:

$$d = \frac{D}{[(10L/KD)+1]^{0.25}}$$

This means that if D is in millimetres of the pipe used in the field for the system and L is its length in metres, the equivalent friction loss shall be created by using an orifice plate of diameter d. It shall be noted that while using this equation, L value shall be taken as the length of pipe in the field minus the length of pipe used in factory set-up for substituting in the equation, equivalent friction loss shall be created by using an orifice plate of diameter d.

C-3 DIAMETER OF ORIFICE PLATE FOR THE ANNULAR AREA OF PACKER/DUPLEX TYPE PUMP

The frictional loss in the annular area for the pressure pipe portion of a packer/duplex type pump is given by :

$$h_f = f\left[\frac{L}{(D_o - D'_d)}\right]\left[\frac{Q}{\pi/4\,(D_o^2 - D'^2_d)\times(1/2g)}\right]$$

$$= \left[\frac{Q^2}{(\pi/4)^2\times 2g}\right]\times\left[\frac{L}{D_o - D'_d)\,(D_o^2 - D^2_{d'})^2}\right] \quad \ldots(1)$$

If an equivalent pipe of inner diameter D_a and length L_e is selected to give the same amount of head loss in friction as a single pipe,

$$h_f = f L_e(1/D_a) \times \left[\frac{Q^2}{(\pi/4)^2 \times D_a^4} \right] \times (1/2\,g)$$

$$h_f = \left[\frac{fQ^2}{(\pi/4)^2\, 2\, g} \right] \times \left[\frac{L_e}{D_a^5} \right] \qquad \text{......(2)}$$

Equating equations (1) and (2), we get

$$(L_e/D_a^5) = L \times \left[\frac{1}{(D_o - D'_d)\,(D_o^2 - D'^2_d)^2} \right]$$

D'_d is outer diameter of the delivery pipe of jet unit for packer/duplex

$$L_e = D_a^5 \left[\frac{L}{(D_o - D'_d) \times (D_o^2 - D'^2_d)^2} \right]$$

So in the packer/duplex type, the orifice plate is set in a horizontal length above the duplex/packer head using a pipe of convenient diameter D_a for the pressure pipe. For this pipe dia, the equivalent length L_e is calculated for the annular actual pipe length, L, used in the field.

Then to create the frictional loss, an orifice plate of diameter d_a is selected so that:

$$d_a = \left[\frac{D_a}{[C^2\,(fL_e/D_a) + 1]^{1/4}} \right]$$

Where L is in metres and D is in millimetres.

Then

$$d_a = \left[\frac{D_a}{[\,(10L_e/KD_a) + 1]^{1/4}} \right]$$

Diameter of orifice plate to be used in the horizontal equivalent pressure pipe line is :

$$d_a = \left[\frac{D_a}{[\,(10L_e/KD_a) + 1]^{1/4}} \right]$$

C-4 MODEL CALCULATIONS FOR SELECTION OF ORIFICE PLATE OF TWIN TYPE JET PUMP

C-4.1 Example 1: (*see* Fig. 6 *and* 7)

Calculate the diameter of orifice plates to be used in twin type centrifugal jet pump of size 50 mm × 40 mm — Delivery pipe of jet assembly (suction pipe of centrifugal pump) × pressure pipes.

The duty point ground to low water level is 25 m and at duty point, the pump requires four metres submergence and the pump is a vertical pump having one metre pipe above the ground level, medium class pipes are used in the factory set-up, three metre length is used for testing with 2.5 m submergence.

L_f = length of pipe used in field.

= ground to low water level + submergence + vertical distance above the ground level to centrifugal pump.

= 25 + 4 + 1 = 30 m.

L = Length of pipe to be taken for friction calculation.

= pipe length used in field —pipe length used in test set up.

= 30–3 = 27 m.

The inner dia of 50 mm medium class pipe is

D_d = 53 mm

The inner dia of 40 mm medium pipe is

D_p = 42 mm

The diameter of orifice plate for the delivery side of the jet pump (which in turn is the suction pipe of centrifugal pump)

d_d = Diameter of orifice plate in jet pump (Assembly) delivery, which is the suction pipe of centrifugal pump.

$$= \frac{D_d}{[\,(10L/KD_p) + 1]^{1/4}}$$

$$= \frac{53}{[\,270/(0.9 \times 53) + 1]^{1/4}} = 32.99 \text{ mm}$$

Since the legnth of the pressure pipe also is the same, diameter of orifice plate in pressure pipe

$$d_p = \frac{D_p}{[\,(10L/KD_p) + 1\,]^{1/4}}$$

$$= \frac{42}{[\,(270/0.9) \times 42 + 1]^{1/4}} = 24.86 \text{ mm}$$

So the above size of orifice plates are fitted to the delivery pipe of jet pump (Assembly) which is the suction pipe of centrifugal pump and pressure pipe of jet pump (Assembly). It is always convenient to have the centrifugal pumps in a horizontal position for both vertical and horizontal sets for easy test set-up.

C-4.2 Example 2 (*see* Fig. 3 and 8)

Calculate the diameter of orifice plates for the same

centrifugal jet pump if it is of a horizontal packer type/duplex type using an 80 mm outer pipe, 50 mm inner pipe and in the horizontal position it uses 50 mm equivalent pressure pipe.The length of vertical concentric pipe used in the field is 25 m ground to low water level, four metre submergence and three metre horizontal pipes of 50 mm each, including the equivalent length for the bend. In the factory test set-up, the length of concentric pipes used is three metres and in the horizontal portion two pipes of 50 mm of two metres length is used including the equivalent length for bends. In all cases, medium class pipes are used. The submergence at factory set-up is 2.5 m.

The pump centre line in both field and factory set-up above ground level is one metre.

Calculation :

For the inner pipe

Length of inner pipe at field

= 25 + 4 + 4 = 33 metres.

Length of pipe used in factory set-up

= 2 + 1 + 3 = 6 metres.

Length of pipe L_d used for friction calculation
= 33 – (2 + 1 + 3) = 27 metres

(Refer Fig. 9 and Fig. 10)

D_d = inner diameter of inner pipe = 53 mm, that is, delivery pipe of jet pump. Therefore, diameter of orifice plate,

$$d_p = \frac{D_p}{[\,(10L_d/KD_d) + 1\,]^{1/4}}$$

For the annular pipe

D_o = inner dia of outer pipe of 80 mm
= 80.8 mm

D_d = outer diameter of inner pipe which is the delivery pipe of jet pump
= 60.3 mm

Length of concentric pipe used in the field:
25+4 = 29 m

Length of pipe used in the factory set-up: 3 m

L_e = Length to be taken for calculating friction : 29–3 = 26 m

Let D_e = Diameter of equivalent pipe
= Diameter of pipe used in pressure pipe
= 53 mm

This equivalent length for pressure pipe,

$$L'_e = (D_e)^5 \times \frac{L}{[\,(D_o - D'_d)\,(D_o^2 - D'^2_d)^2]}$$

$$= (53)^5 \times \frac{26}{[(80.8 - 60.3)\,(80.8^2 - 60.3^2)^2]}$$

$$= 63.39\ \text{m}$$

Length L_e to be taken for friction calculation

$= L'_e + (3+1-2-1)$

$= 64.39$ m

Diameter of orifice plate to be used in equivalent pipe for the annular area

$$= \frac{53}{[\,(643.9)/(0.8 \times 53) + 1\,]^{1/4}}$$

$= 26.42$ mm

ANNEX D

(*Clause* 10)

EXAMPLE TO CHECK THE DECLARED VALUES

D-1 A centrifugal jet pump of nominal 0.75 kW rating has following declared values :

DLWL	:	25 m
DLWL Range	:	18 to 30 m
Discharge	:	1 000 l/h
Total head	:	44 m
Power input	:	1.2 kW
Maximum current	:	6.0 A

In this figure lines have been drawn given for the declared values and also 92 percent of discharge, 92 percent of total head, 92 percent of DLWL, 110 percent of power input and for 107 percent of the maximum current declared in the DLWL range. Characteristic curves have been drawn of four jet pumps of above declared values. The hatched portions shown in the figure show the areas of deviation permitted (on the negative side) in respect of discharge *vs* DLWL and discharge *vs* total head.

If the characteristic curve passes through the hatched portion or is above the hatched portion the sample pump conforms to the requirements. Similarly if the discharge *vs* input, power curve is below 110 percent line, that is, in this case 1.32 kW (= 1.2kW × 1.1) at the duty point of 1 000 l/h the sample pump satisfies the requirements. Thus of the four pumps whose characteristic curves are given in the Fig.14, Fig. 15 and Fig. 16.

i)	Sample 1	:	Satisfies the requirements
ii)	Sample 2	:	Fails in input power, since at the duty point the input power is 1.34 kW.
iii)	Sample 3	:	Fails in discharge vs DLWL
iv)	Sample 4	:	Fails in maximum current in the operating range of DLWL.

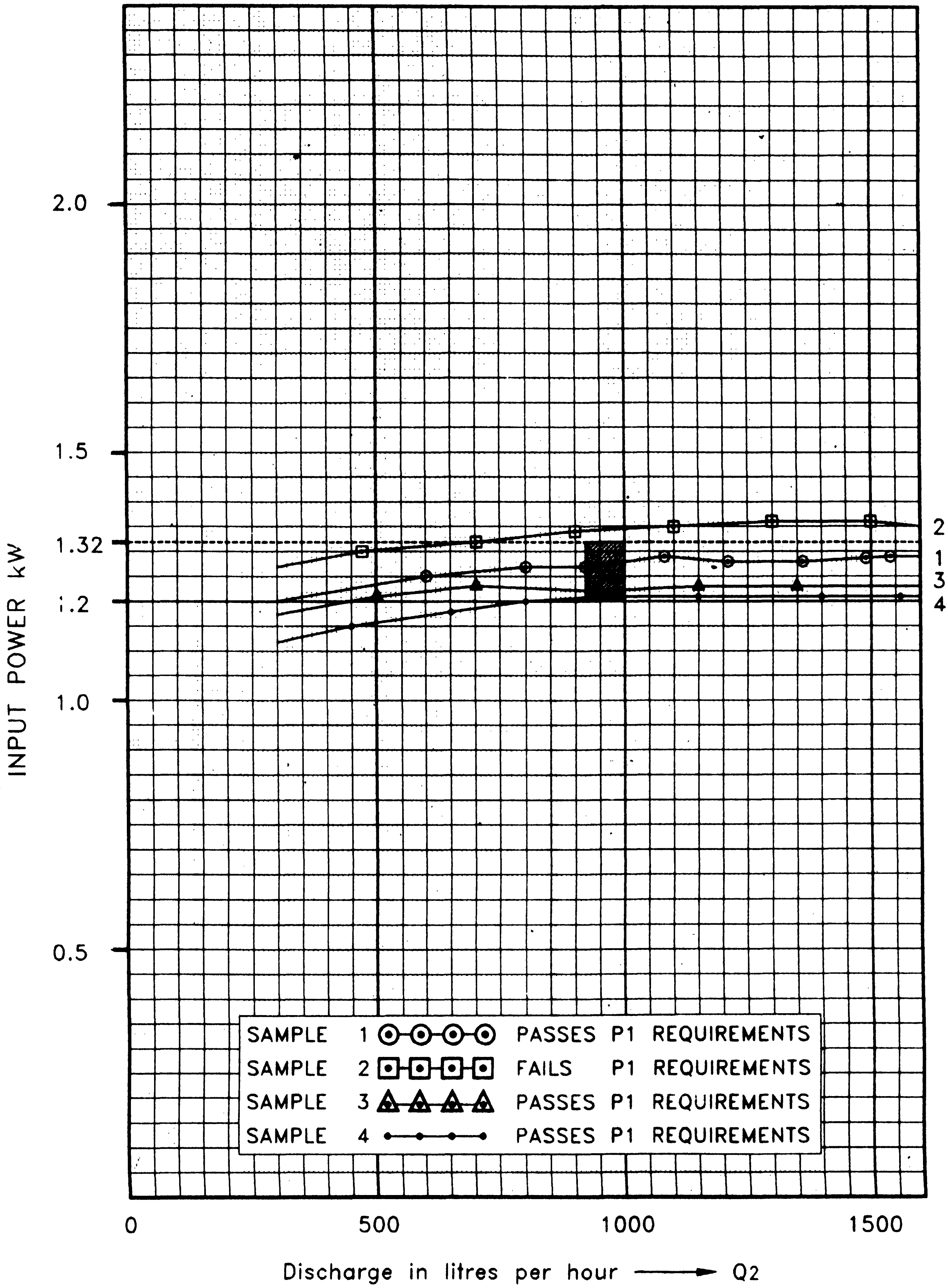


FIG. 14 INPUT POWER *vs* DISCHARGE

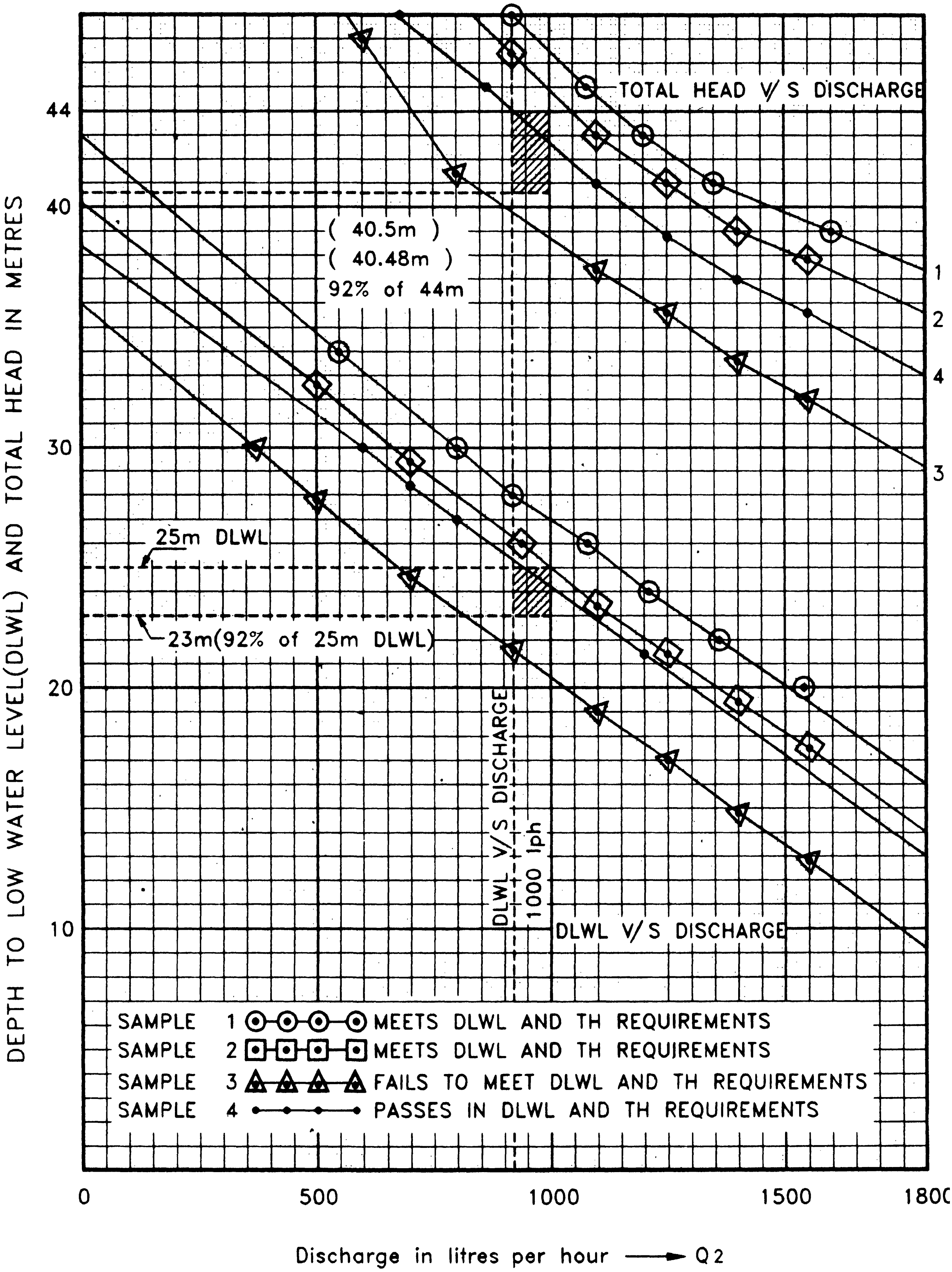


FIG. 15 DISCHARGE *vs* DLWL AND TOTAL HEAD

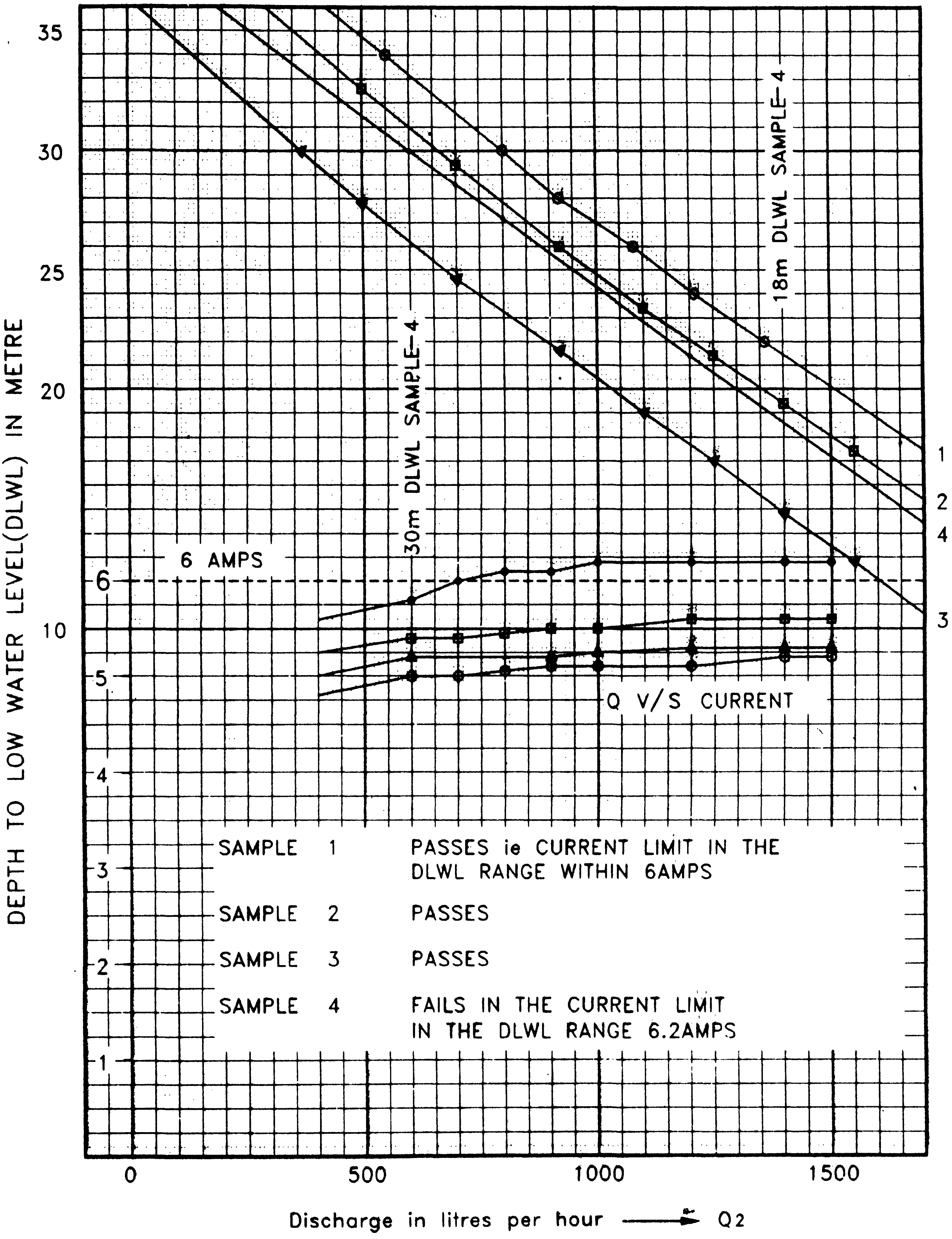


FIG. 16 DISCHARGE *vs* CURRENT AND DEPTH TO LOW WATER LEVEL

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